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A New Fire Protection Concept for Electronic Equipment

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A new fire protection system has been developed to protect shipboard electronic equipment from the intense heat of fire and the potential damaging effects of smoke and fire extinguishing agents. The system will permit the equipment to function even while it is engulfed in a fire. This report describes feasibility tests of this new fire protection concept.

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A NEW FIRE PROTECTION CONCEPT FOR ELECTRONIC EQUIPMENT

INTRODUCTION

In 1981 a new fire protection concept for electronic equipment was developed to counter the problems of fire damage to electronic equipment on board Navy ships [1]. This concept, which can be applied to any type of cabinet, involves making the cabinet watertight by the use of gaskets (to seal doors, etc) and O-rings (on cabinet penetrations and controls) and providing the cabinet with a water spray system. In the event of a fire, the water spray is activated to provide a film of water over all exterior surfaces to protect the cabinet from the heat of fire. During normal operations the cabinet is cooled by drawing air from outside the electronic space through ducts which also enclose the cables leading to the electronic equipment. The provision of drawing air from outside of the space precludes the possibility of injesting smoke-ladened air into the cabinet in the event of a fire within the compartment.

The feasibility of this concept was successfully demonstrated in 1983 under a Navy sponsored program at Brookhaven National Laboratory. The protection concept was applied to a 10" color TV which was subjected to a diesel fuel fire for 20 minutes. The TV survived the fire and continued to function [1]. Subsequently, the system was used to demonstrate its application to two different types of Navy electronic equipment in a joint Brookhaven/Naval Research Laboratory project [2]. In the first demonstration, the system was used to protect a full scale Navy electronics equipment cabinet containing Navy telecommunications equipment. Subsequently, the system was used to protect a Navy surface search radar. This report summarizes the results of all three test programs.

THE EXPERIMENTAL TEST PROGRAM

(1) The TV Demonstration Test

A commercial 10" color TV (Quasar Model WP2132VW; 1982) was chosen to verify the feasibility of the proposed electronic equipment fire protection concept since the modern TV set has electronic components such as CRT tube, integrated circuits and controls, etc. which are sensitive to heat and are representative of most modern electronic equipment. In addition, the continuous audiovisual signals provide a positive indication that the TV is working during fire tests.

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In preparation for the fire test, the original TV enclosure was replaced by a double wall watertight enclosure as shown schematically in Figure 1. The enclosure wall is made of standard circuit board material which is 1/16" thick fiber glass composite sheet with 0.001" copper cladding. UHF, VHF and ON-OFF/Volume controls were made watertight by using standard commercial O-ring seals. Slicone rubber (RTV) was used to seal the picture tube window. The window glass is 1/8" thick coated Pyrex designed to reflect infrared radiation and transmit visible light. Cooling air was provided by a commercial muffin fan rated at 105 SCFM. Cooling water was provided by four nozzles manufactured by Spraying Systems Company, Wheaton, IL. Each nozzle provides a 1.1 GPM square spray mist pattern at 40 psi. Flow rates of cooling air and water were not specifically monitored during the test. However, the air flow rate was estimated to be around 50 SCFM and the total water flow (4 nozzles) was about 2 GPM.

Six type K thermocouples were installed inside the TV at different locations. In addition, two thermocouples were located away from the steel pans which surrounded the TV to measure the ambient temperature. The pans were filled with diesel fuel. The entire setup was enclosed on three sides by fire walls. The experimental setup is schematically shown in Figure 2. The fire lasted about 20 minutes. The test was recorded by video tape and still pictures (Figure 3). The internal temperature profile during the test was also recorded and is shown in Figure 4. The maximum internal temperature was 29.5°C, or about 6° above ambient. The TV survived the test and continued to function.

(2) The Environmental Cabinet Demonstration Test

A standard Navy environmental cabinet (CY4516) was chosen to house the Navy telecommunication system for the demonstration test (Figure 5). This cabinet has double walls and is provided with four blowers rated at 125 SCFM each. It was necessary to modify this cabinet to change the cooling air flow path so that the cabinet could be made watertight. The four blowers at the bottom of the cabinet were removed and a single 500 SCFM fan was installed on the top of the inner enclosure as shown in Figure 6. The original exhaust at the top of the cabinet was sealed and exhaust outlets provided at the base of the cabinet. The cooling air was drawn from outside of the fire compartment and introduced at the bottom of the cabinet as shown. Water cooling was provided by one inch diameter brass tubing with 1/16" holes spaced at 1" apart placed at the top of the cabinet on all four sides. This caused the water to flow down the walls of the cabinet, as shown in Figure 7, without spilling on to the fire. A small nozzle was placed on top of the cabinet to provide cooling water for the cabinet top. [Standard house gutters were used to collect water flowing down the cabinet walls (not shown) and drain pipes were provided to drain the water outside of the compartment.]

The following equipment was installed into this cabinet:

i. The 10" color TV from the previous test.
ii. A small TV camera (GBC Model DV-300) which was used to monitor the function of the teletype during the test.
iii. A Navy teletype, AN/UGC-25A.
iv. A converter (NRL made).
v. A Navy radio receiver (AN-BRR-3).

All units, except the TV camera which was permanently mounted, were installed in the cabinet in the standard way such that they can slide in and out of the cabinet by unfastening screws. The back of the cabinet was also made removable so that all units could be serviced from the rear of the cabinet (Figure 8). This was to demonstrate that maintenance of any of the electronic units installed in this cabinet could be accomplished in the normal fashion with the new fire protection system installed. Furthermore, since the modified cabinet is waterproof, it is impervious to all types of fire extinguishing agents. The same technique was used to seal the cabinet and control penetrations as described previously for the TV.

Eleven type K thermocouples were installed inside the cabinet at various locations as shown in Figure 9. A transmitter was used to continuously transmit messages to two teletypes which were connected in series - one inside the cabinet and the other inside the control room. The operation of the teletype inside the cabinet was monitored on closed circuit TV while the other teletype was monitored visually. The experimental setup was similar to the TV test except that this test was conducted inside a building. Similar fire pans were used to surround the cabinet and heptane fuel was used instead of diesel fuel to minimize the production of black smoke.

The following tests were conducted:

1. With the telecommunication system and the TV turned on and operating continuously, the cabinet was sprayed with three different types of fire fighting agents: CO_2, water and AFFF (Figure 10). These tests lasted about 20 minutes altogether and the electronic systems continued to function normally, thereby demonstrating that electronic equipment protected by this fire protection system will not be affected by any type of fire fighting agents.

2. The telecommunication system and the TV were subjected to a heptane fuel fire for 11 minutes (Figure 11). All units inside the cabinet continued to function during and after the test which was recorded on video tapes and still pictures. The internal temperature profile was recorded and is shown in Figure 12. The maximum internal temperature was 38°C, 15°C above ambient.

3. With the same systems inside the cabinet as in the second test, the cabinet was again subjected to a heptane fuel fire for about 38 minutes. All units survived the test and continued to function.

(3) The Radar System Demonstration Test

A Navy surface search radar, AN/SPS-64V(9), shown in Figures 13 and 14, was selected for the third demonstration. Both the indicator and the transceiver cabinets were fitted with watertight aluminum enclosures and the indicator power switch and range control, which penetrated the indicator cabinet, were fitted with O-rings. GE silicone rubber foam (RTF-762) was used to prepare gaskets for the indicator lid and front door openings. The transceiver has no penetration except the waveguide connection.

The transceiver and indicator were interconnected through a standard home air conditioner duct (8" X 12" rated 500 CFM) as shown in Figure 15. A 500 CFM blower (Boyley Blower Co., Milwaukee, WI) was used for air circulation. Three fuel pans surrounded each unit. Both the transceiver and the indicator were bolted to 1/4 in. thick steel plates (4 ft X 5 ft) to simulate bulkhead mountings. Seven type K thermocouples were installed inside the transceiver and six inside the indicator. Their locations are shown schematically in Figures 15 and 16. For the purpose of this demonstration, four commercial sprinkler nozzles (Spraying Systems Company) were used per unit to spray water onto the cabinet exterior walls. The nozzles were intentionally directed away from the fire pans so that the fire would not be extinguished. The total water flow was about 7 GPM. (In a practical system, ordinary sprinkler heads could be used to extinguish the fire while cooling the cabinets.) The cabinets were enclosed by cinder block walls on three sides and a 1/4 in. thick steel roof, as shown in Figures 15 and 17, to simulate an electronics space. The front side was left open for viewing and video taping. A Winnebago motor home was used as a monitoring station (Figure 15). The radar antenna was mounted on top of the motor home. The following tests were conducted:

Test 1

The radar system was subjected to a heptane fuel fire for 15 minutes as shown in Figures 18 and 19. Heptane was used, rather than JP-5 or diesel fuel, to minimize production of black smoke and to permit the operation of the indicator display to be photographed via remote camera during the fire. Both units survived the test and continued to function during and after the fire. Figure 20 shows the radar indicator working before the fire and Figure 21 shows the indicator working after the fire. The internal temperature rise of both units during the fire test period was insignificant, amounting to a maximum of 4°C after 15 minutes exposure to the fire.

Test 2

The same test was carried out as in Test 1 except the fire duration was about 28 minutes. The internal temperature rise of both units is shown in Figure 22. As in Test 1, the maximum internal temperature rise was small, amounting to less than 6°C above ambient. Both tests were recorded on video tapes and still pictures.

CONCLUSIONS

The above tests positively demonstrated that the proposed fire protection concept is a viable technique for protecting vital electronic equipment from fire damage and to ensure its continued function and survivability in fire environment.

REFERENCES

1. Leonard, J. T., "Fire Protection System for Electronic Equipment," NRL Letter Report 6180-33:JTL:drs, 28 January 1986.

2. Leonard, J. T., "Preliminary Report on a Fire Protection System for AN/SPS-64V(9) Radar," NRL Letter Report 6180-20: JTL:blf, 15 January 1987.

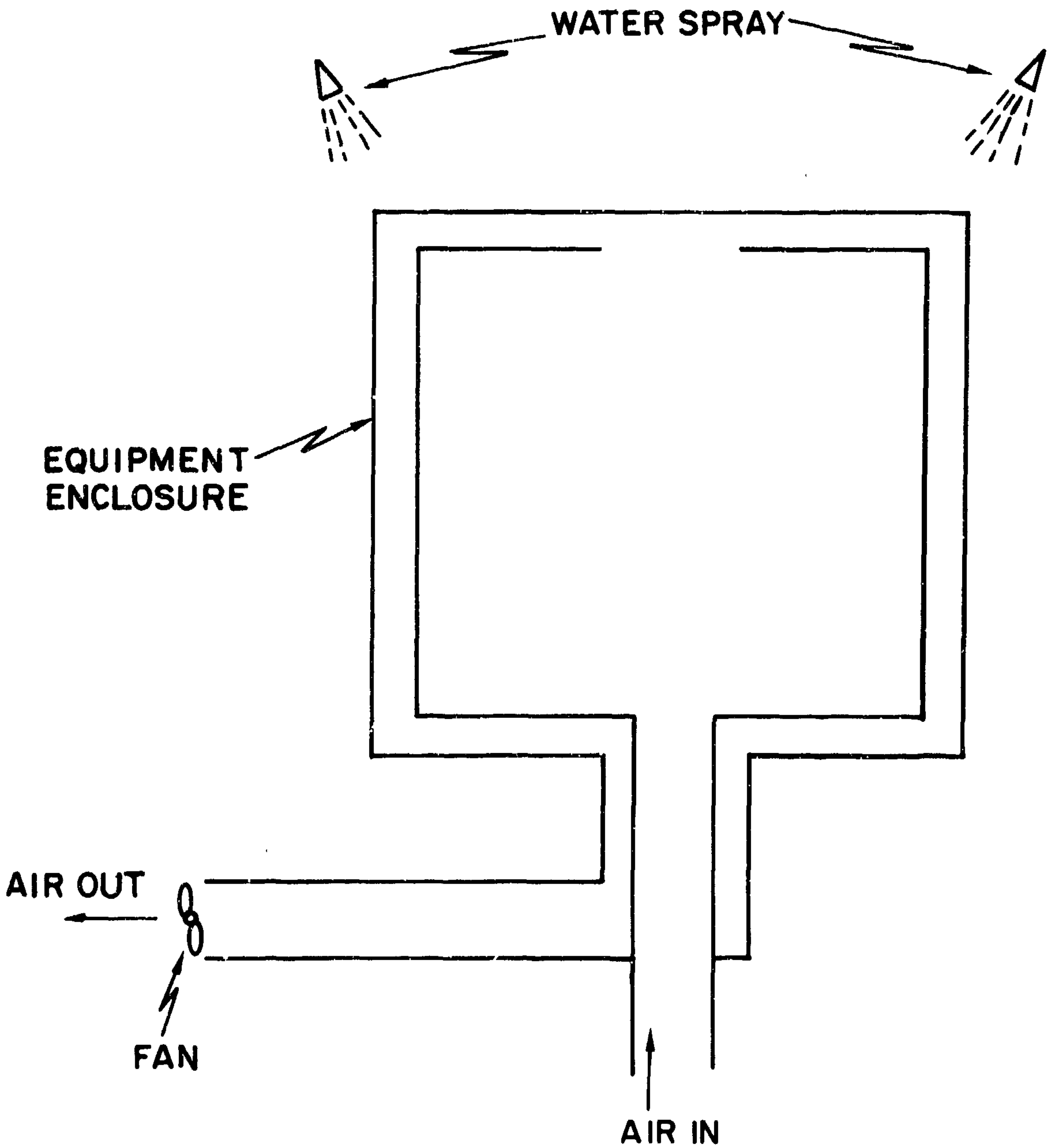


Fig. 1 — Fire protection concept for electronic equipment

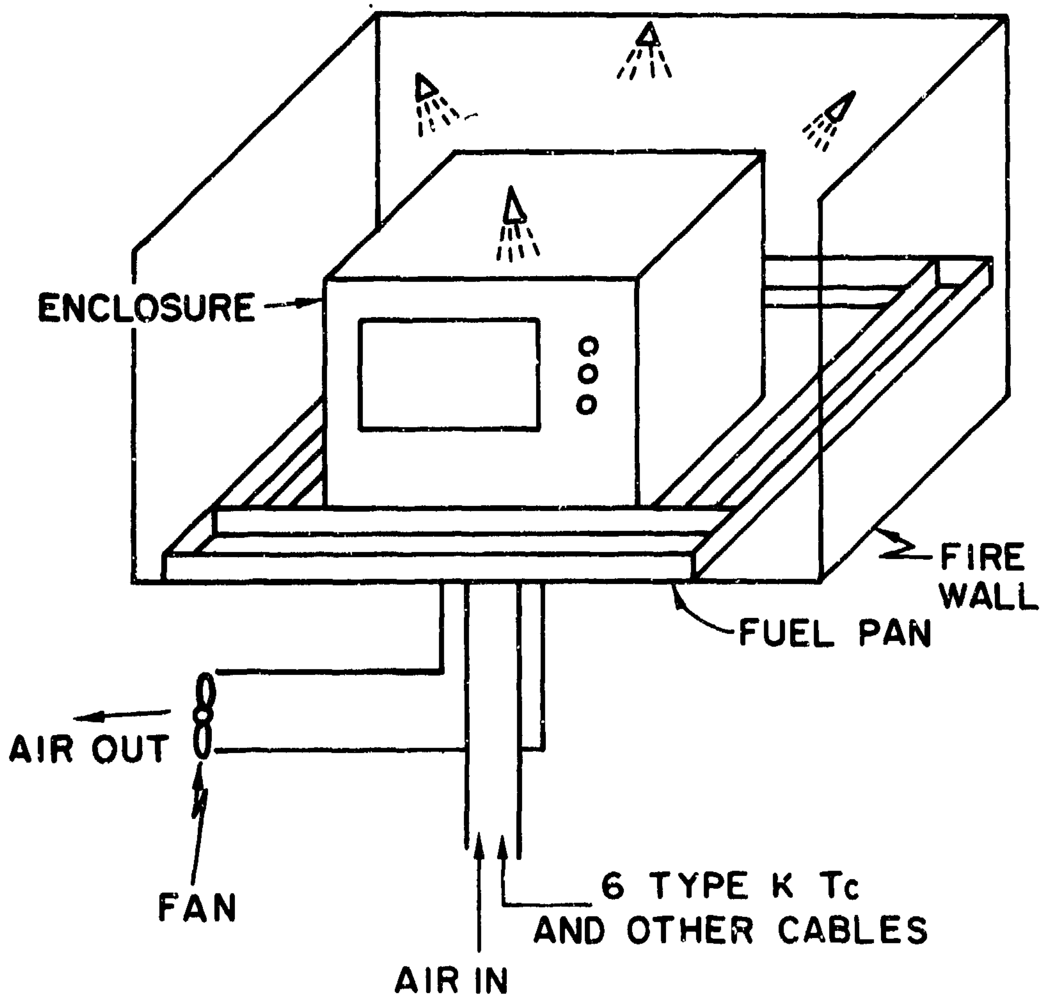


Fig. 2 — Experimental setup for fire test of the 10'' color TV

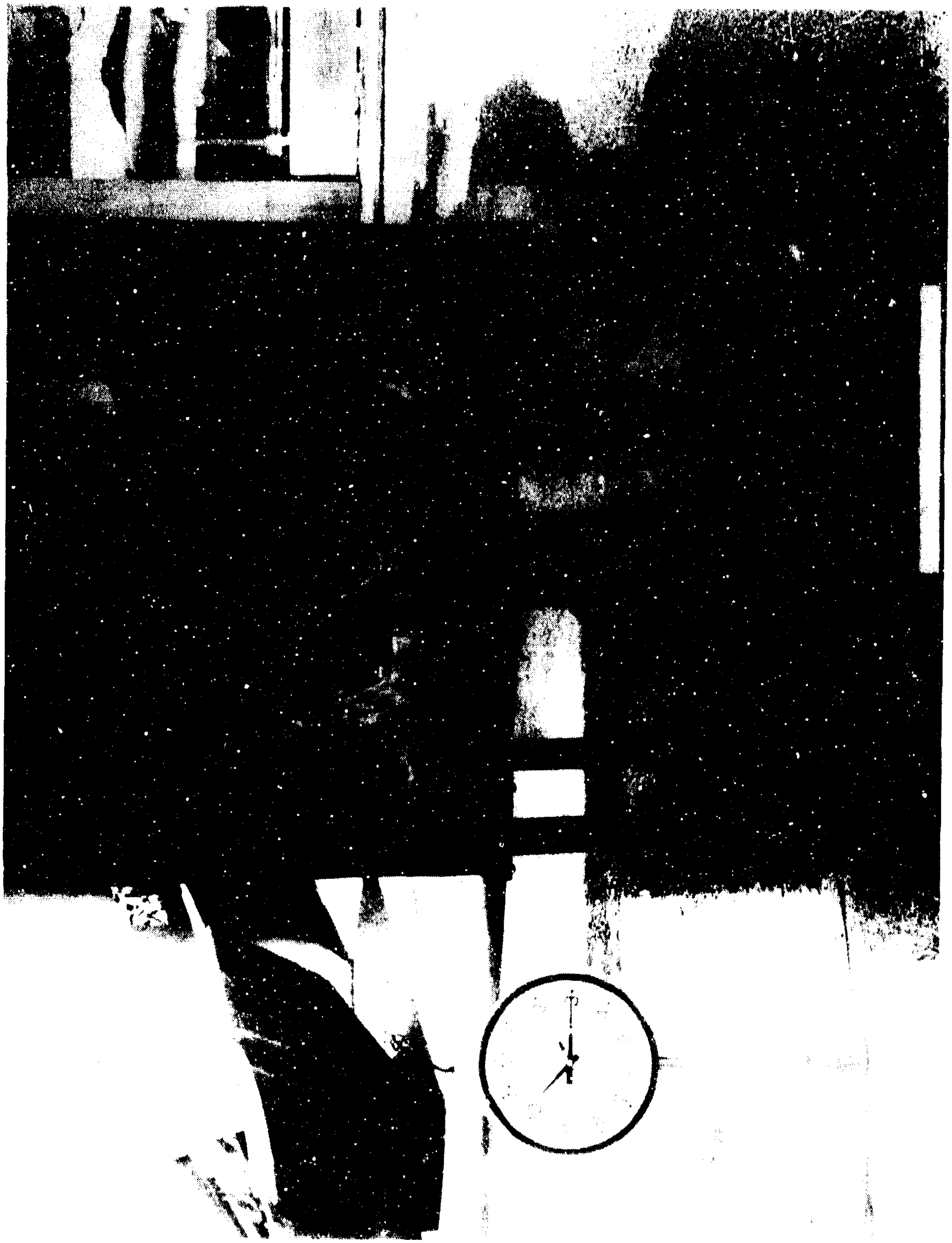


Fig. 3 — Fire test of 10'' color TV

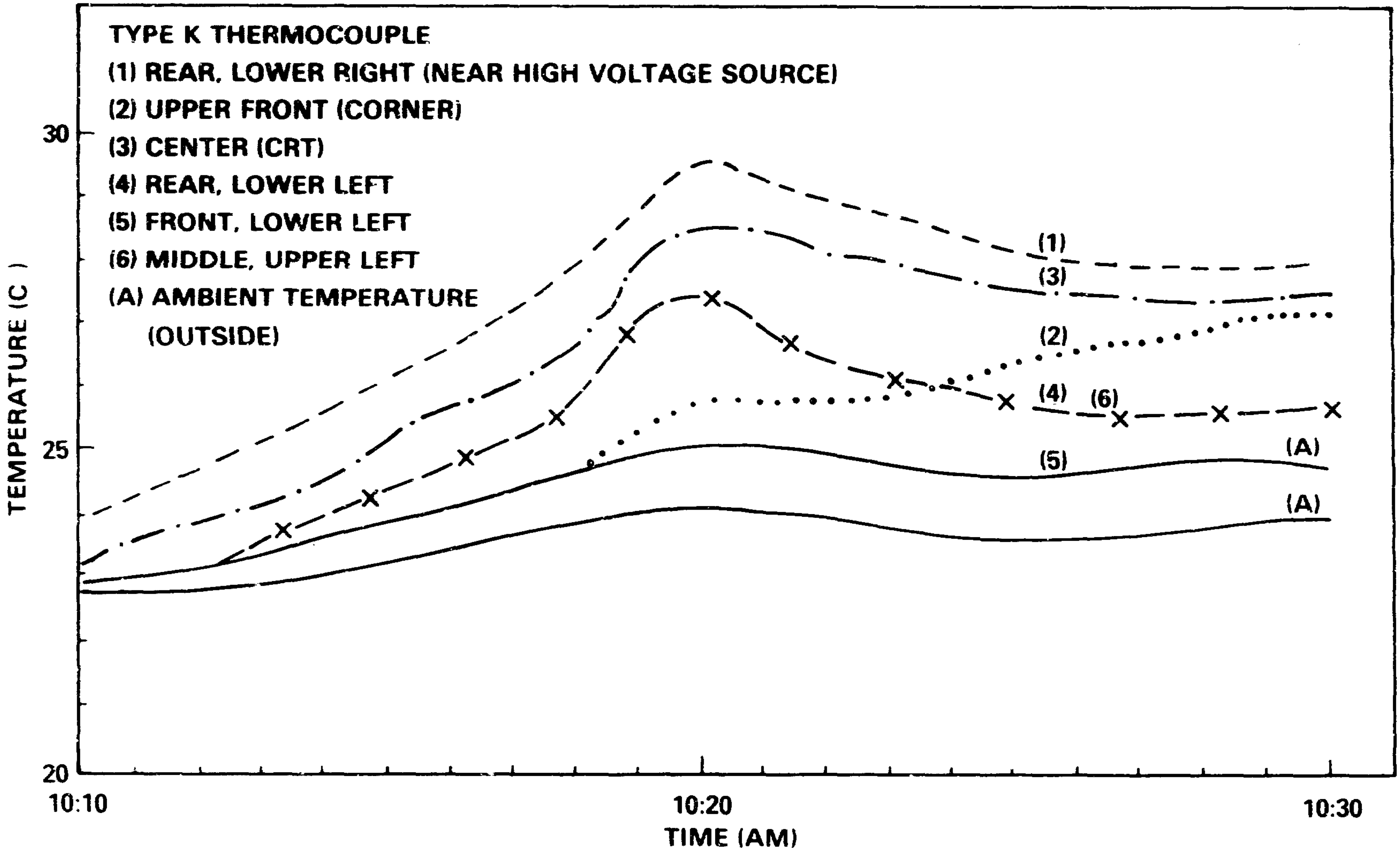


Fig. 4 — Internal temperature profile of TV during diesel fuel test (8/25/83)

Fig. 5 — Navy environmental cabinet (CY4516). Blowers removed and cabinet partially modified for fire test.

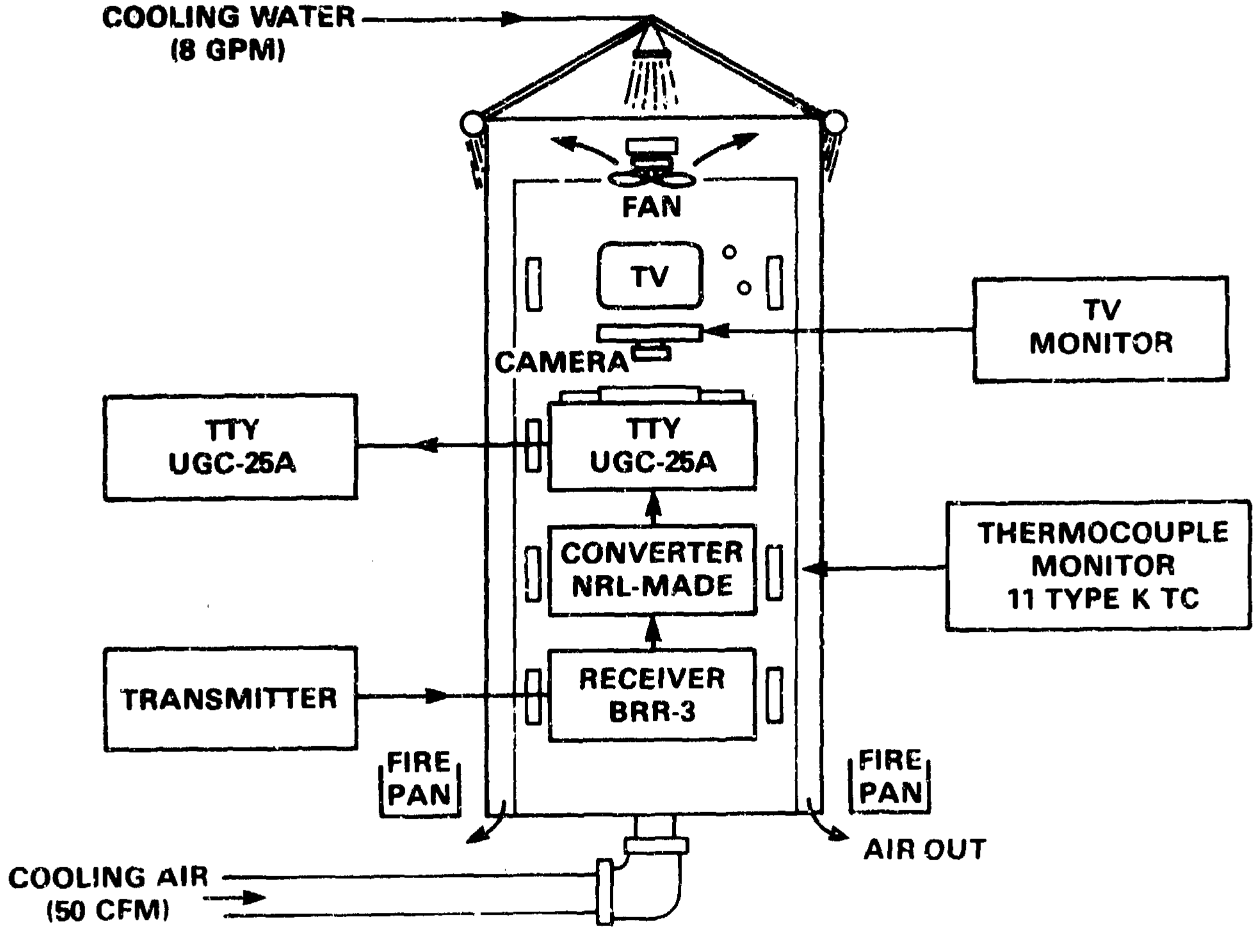


Fig. 6 — Experimental setup for fire test of environmental cabinet

Fig. 7 — Sprinkler system showing water flowing down the cabinet walls

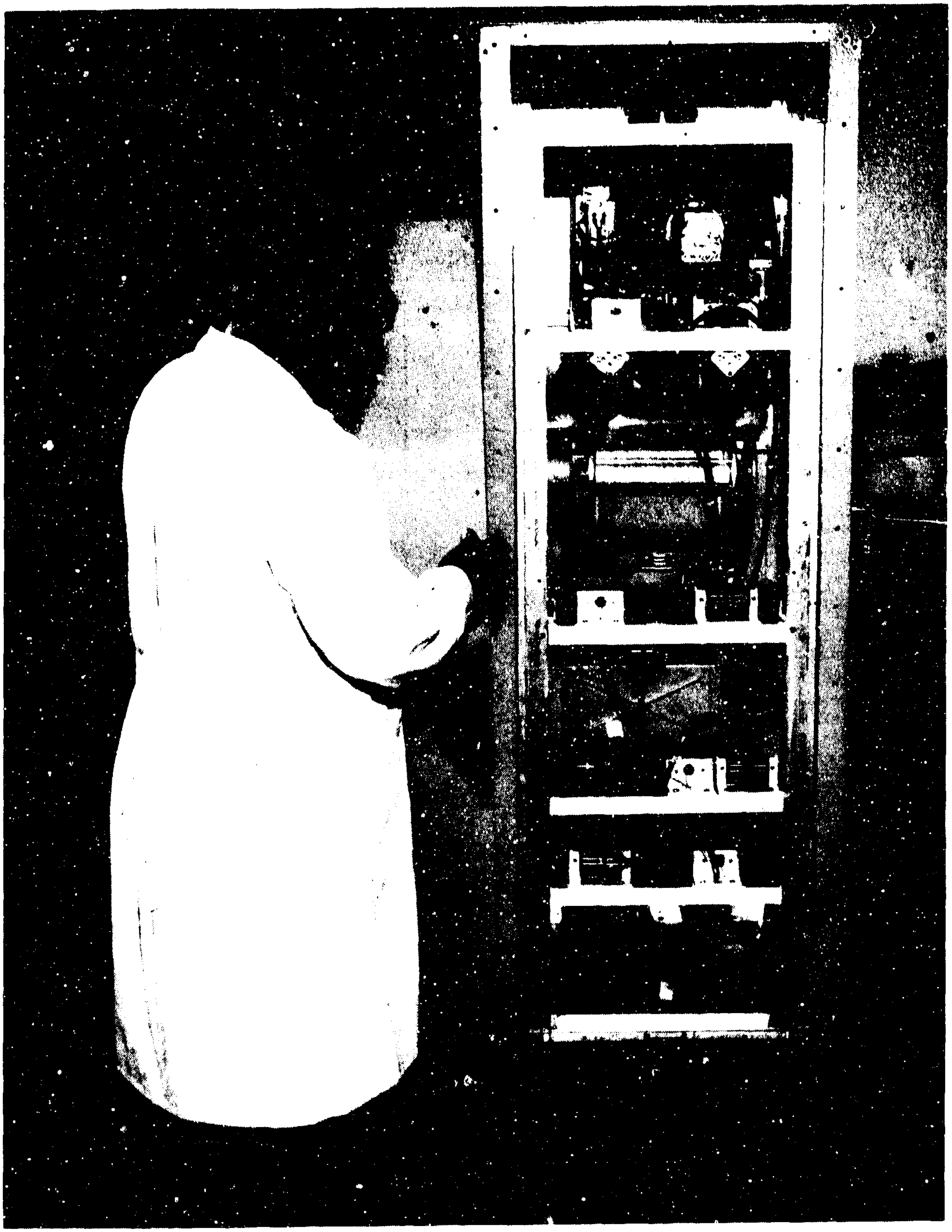
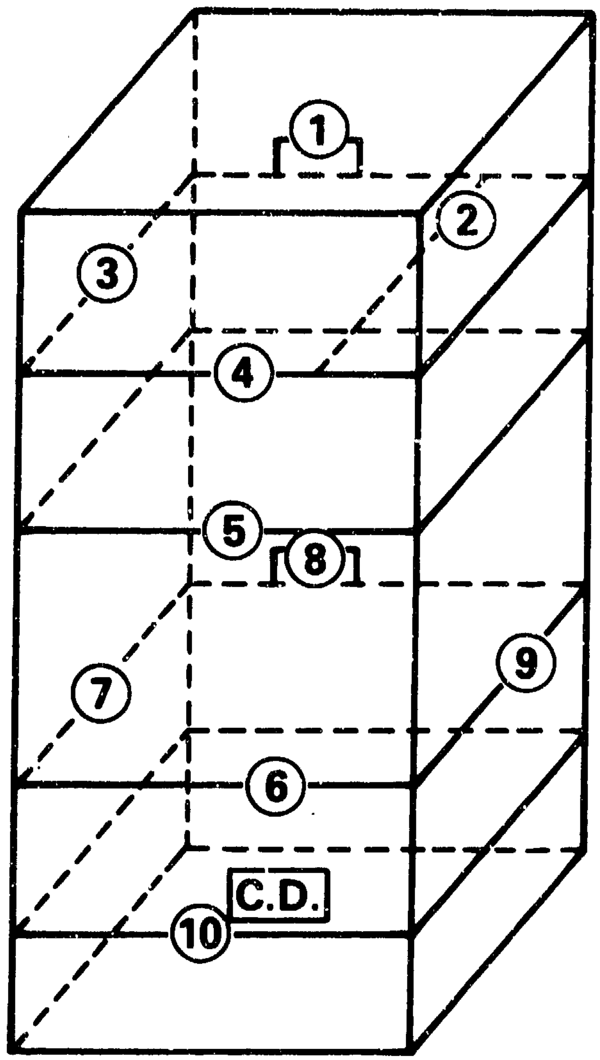


Fig. 8 — Rear view of the cabinet showing accessibility for maintenance

TYPE K TC LOCATIONS INSIDE CABINET



C.D. = CONTINUOUS DISPLAY
0 = INPUT AIR TEMP (AMBIENT)
11 = EXHAUST AIR TEMP

Fig. 9 — Thermocouple locations

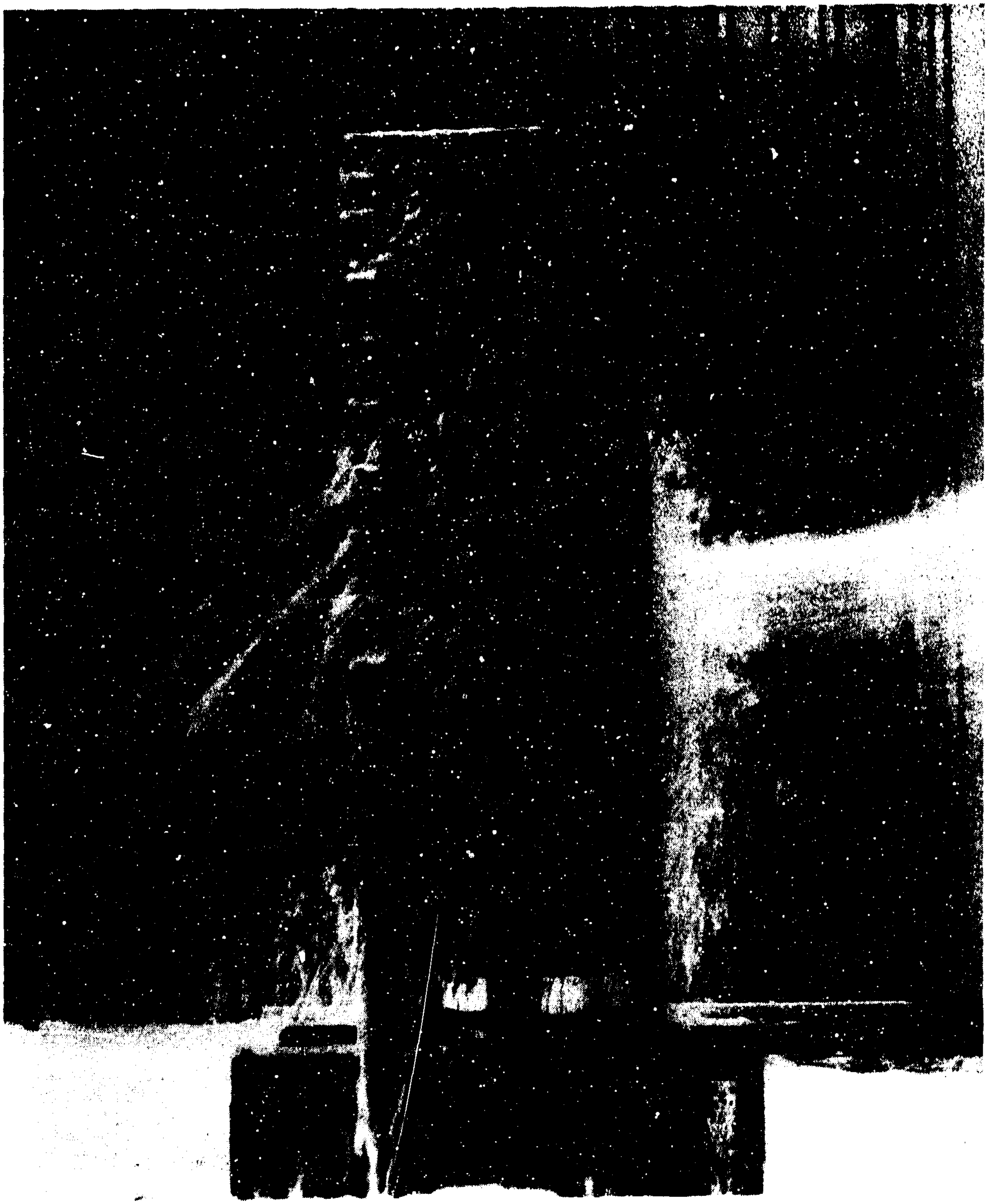


Fig. 10 — Environmental cabinet during AFFF spray test

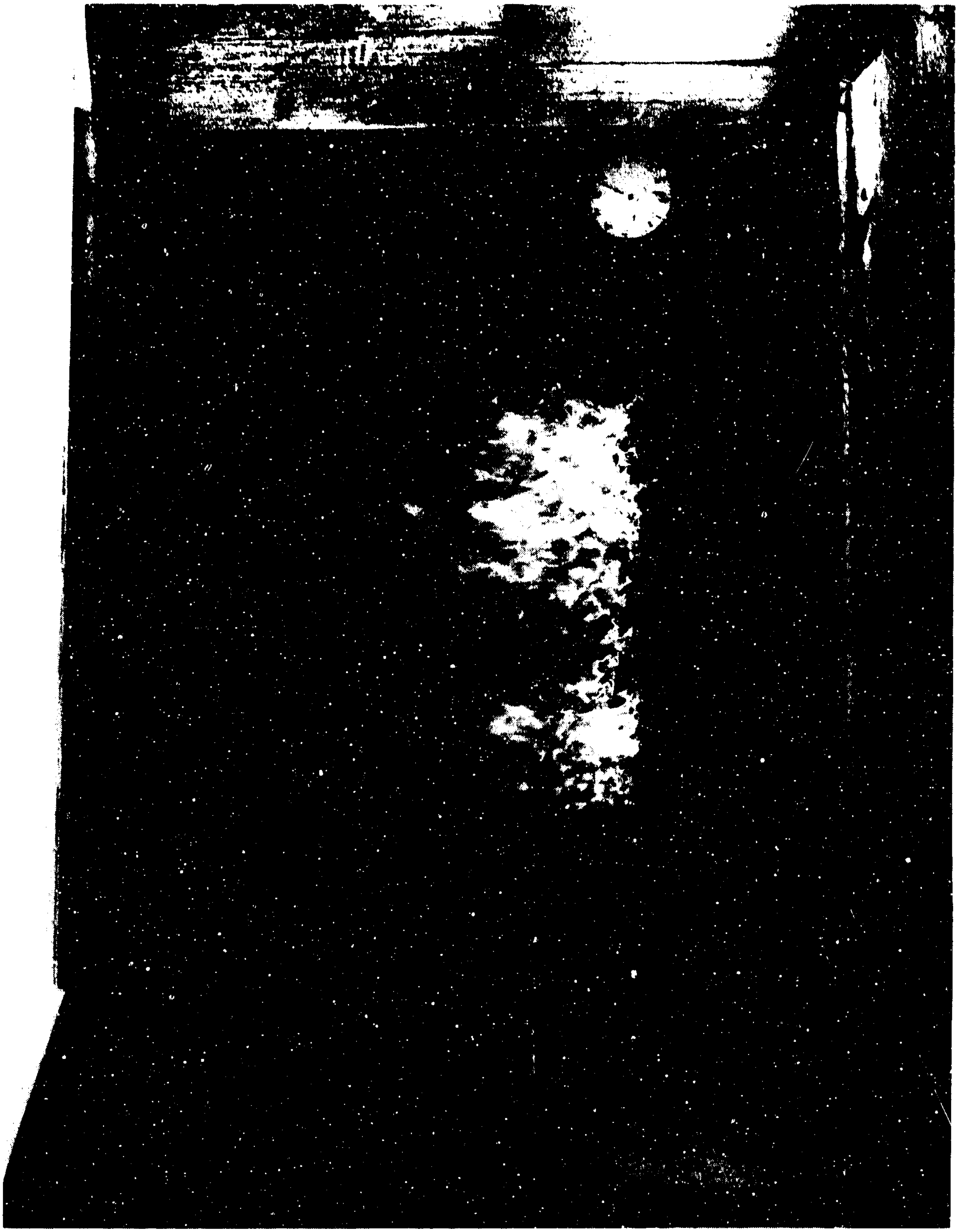


Fig. 11 — Fire test of environmental cabinet

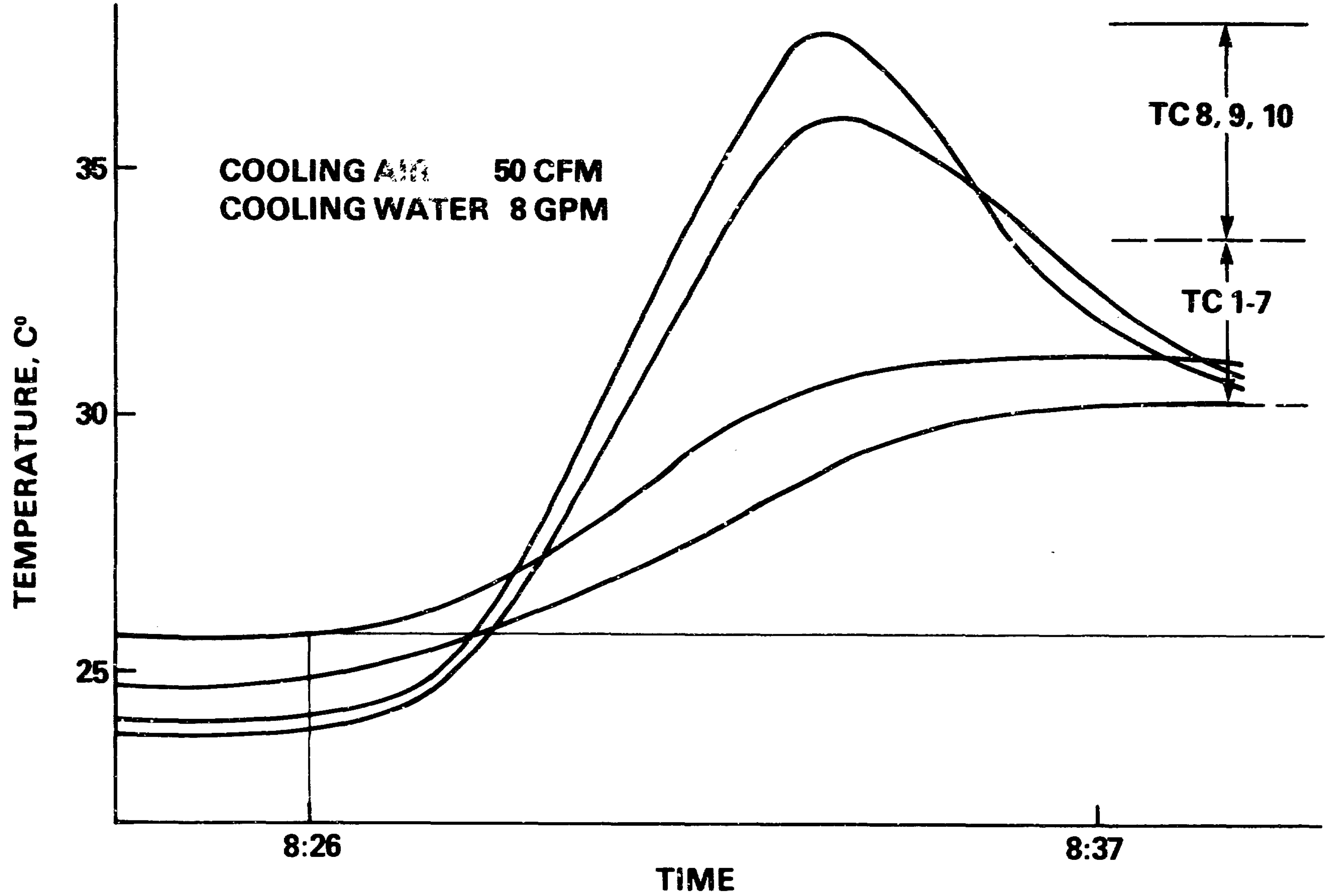


Fig. 12 — Internal temperature of cabinet during fire test

Fig. 13 — AN/SPS-64 V(9) Indicator Cabinet

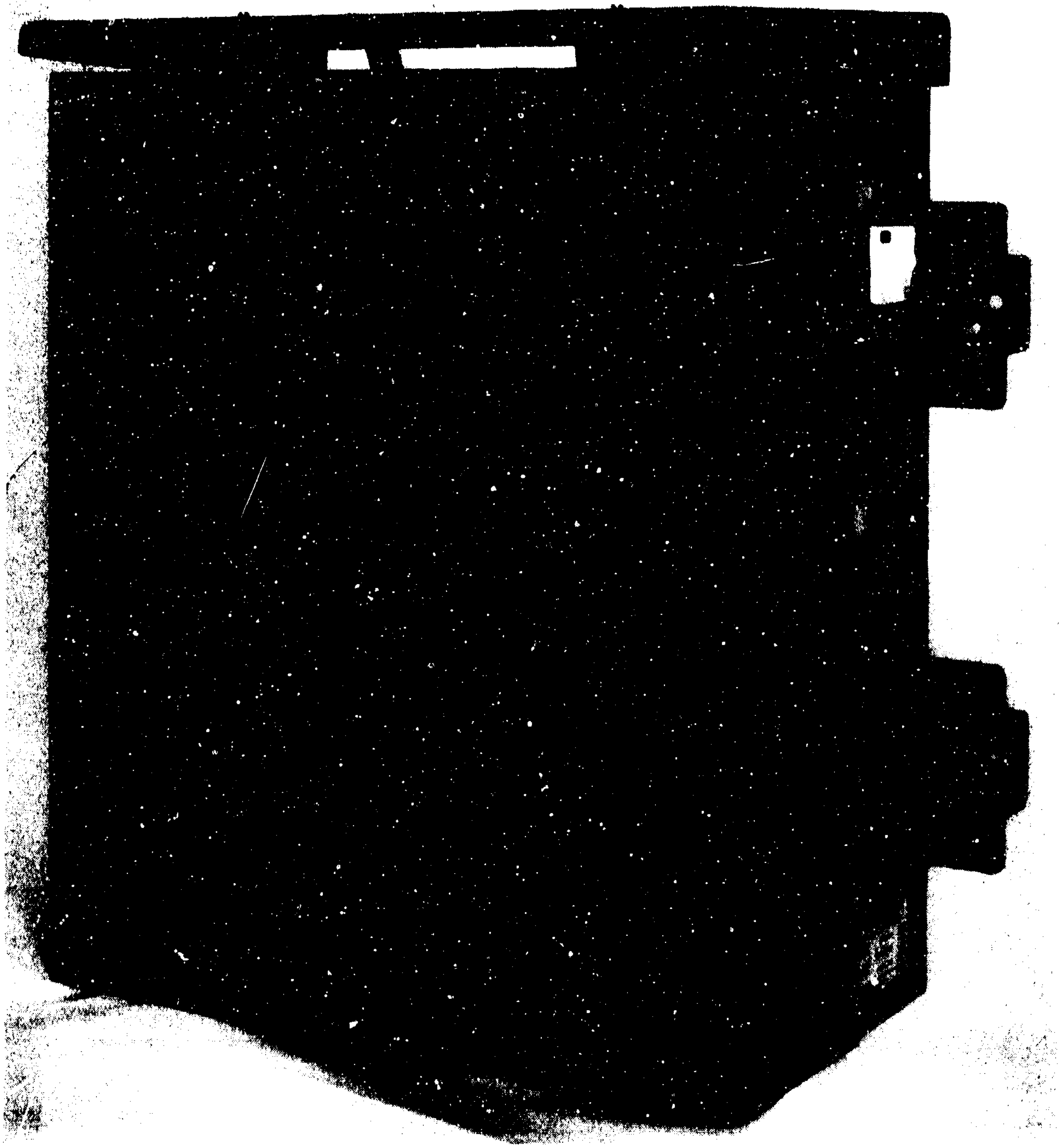


Fig. 14 — AN/SPS-64 V(9) Transceiver

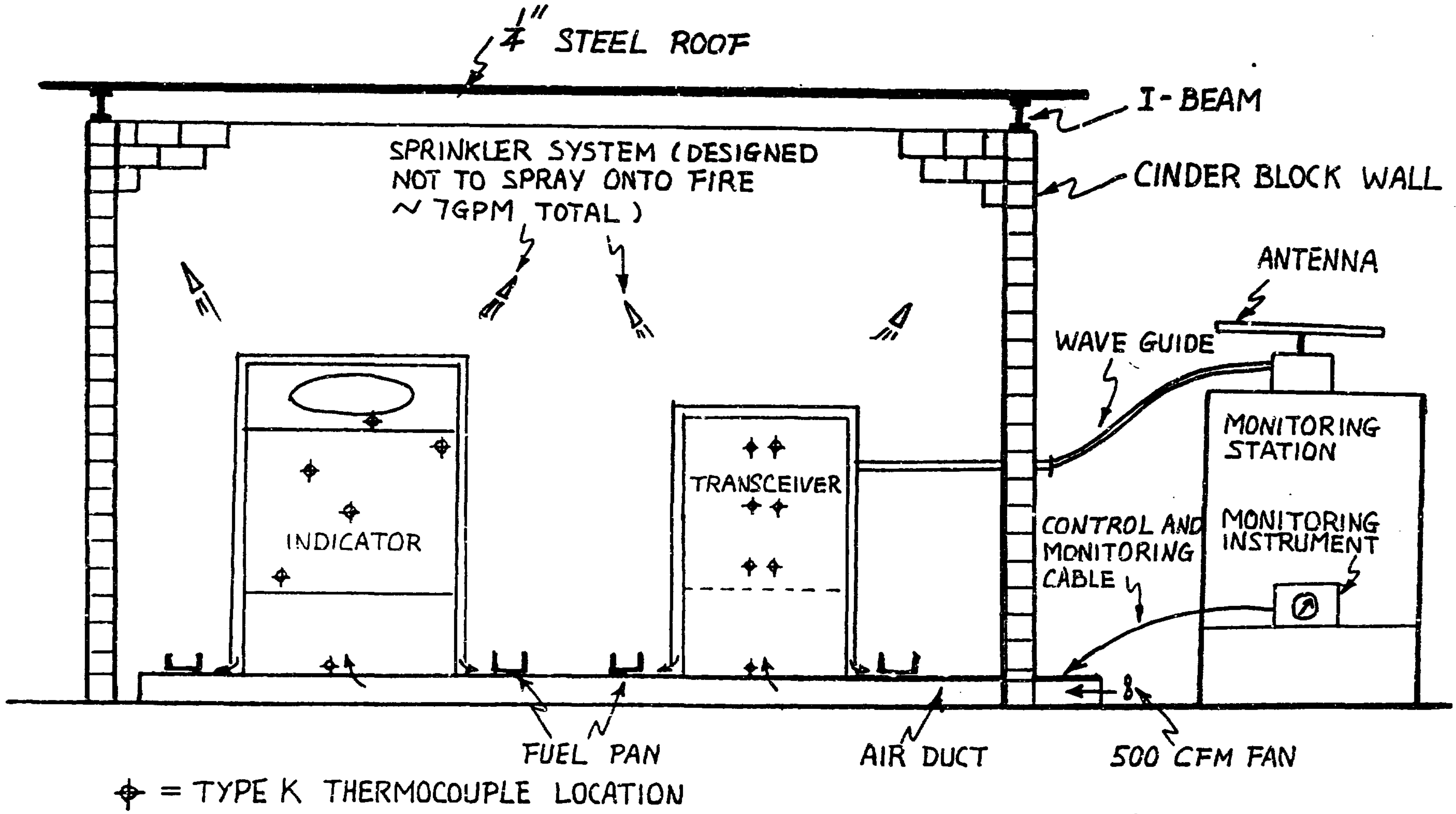


Fig. 15 — Experimental setup of AN/SPS-64 V(9) radar for fire test demonstration.

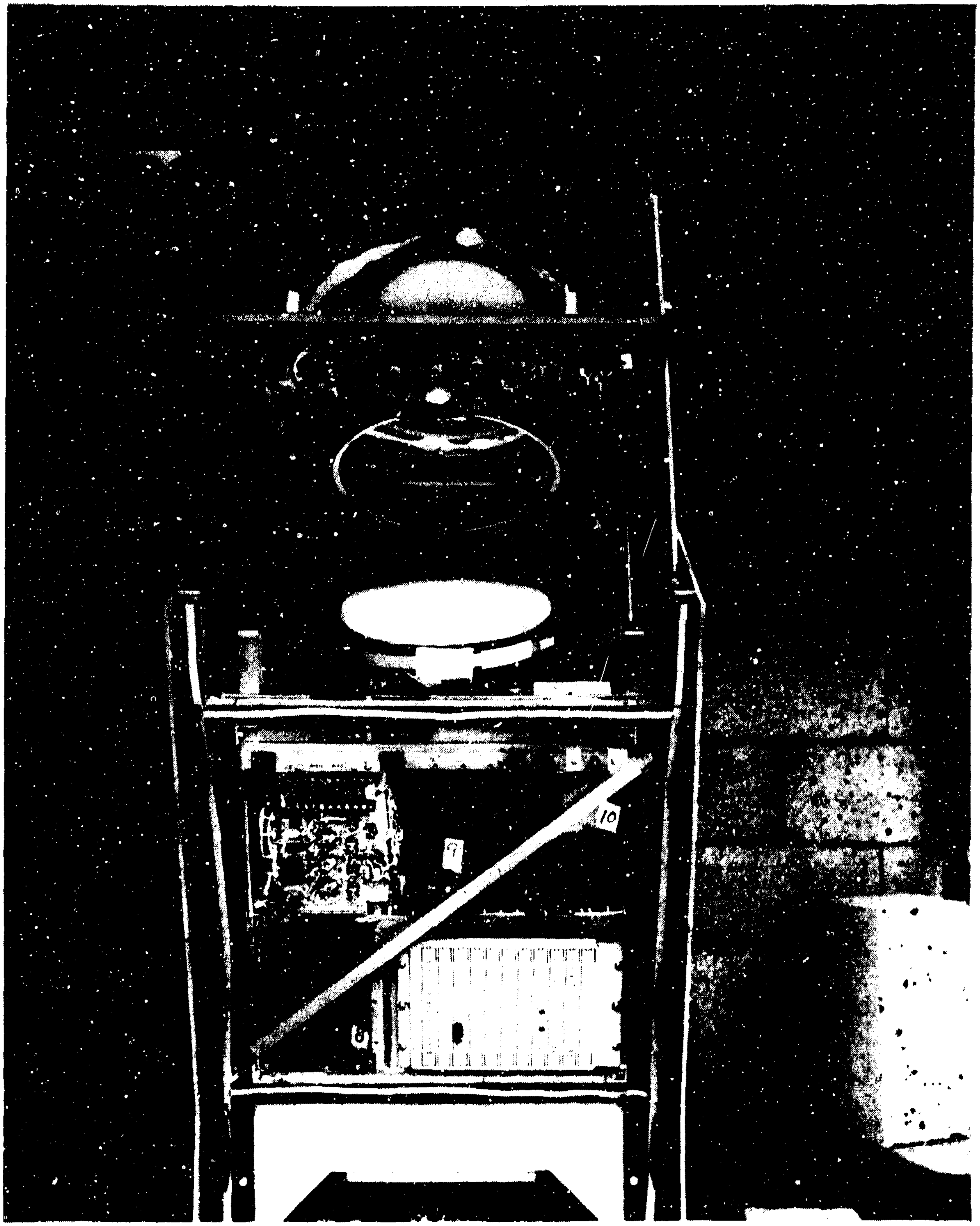


Fig. 16 — AN/SPS64 V(9) Indicator Cabinet showing installation of GE RTF-762 silicone rubber foam gaskets and numbered locations of thermocouples.

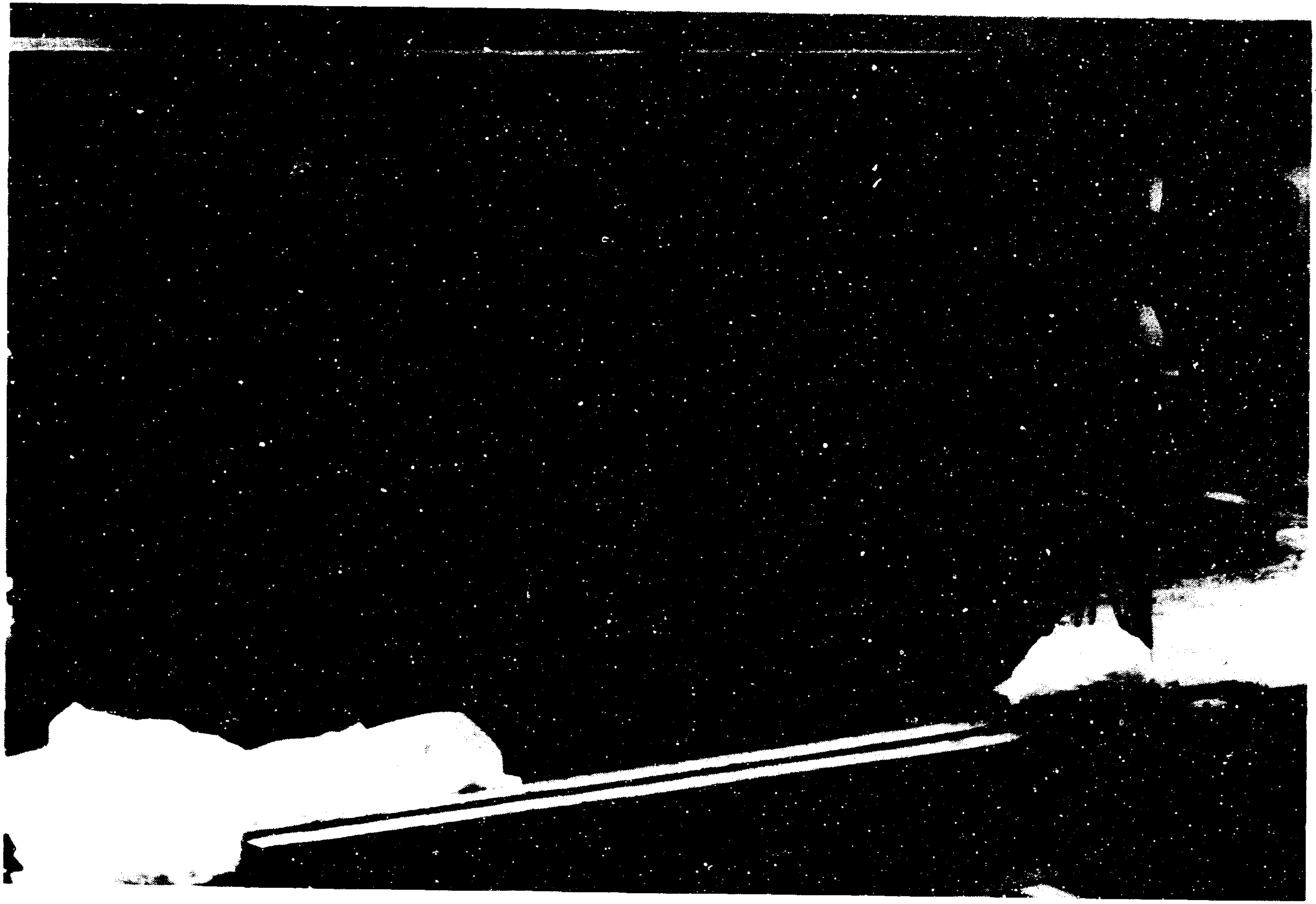


Fig. 17 — Front view of cinder block test cell showing installation of indicator and transceiver cabinets.

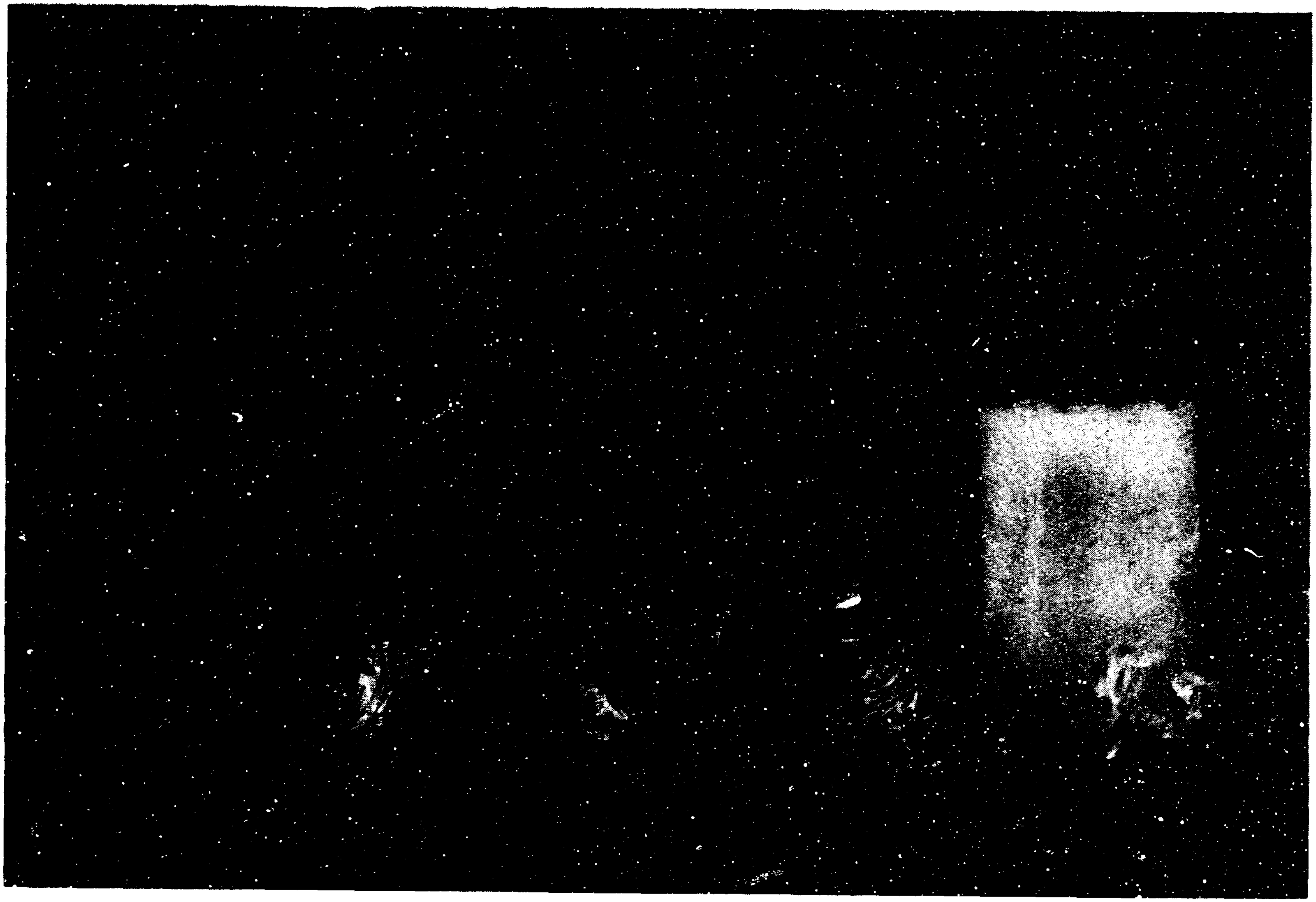


Fig. 18 — Start of fire tests showing operation of water spray system

Fig. 19 — Fire test in progress

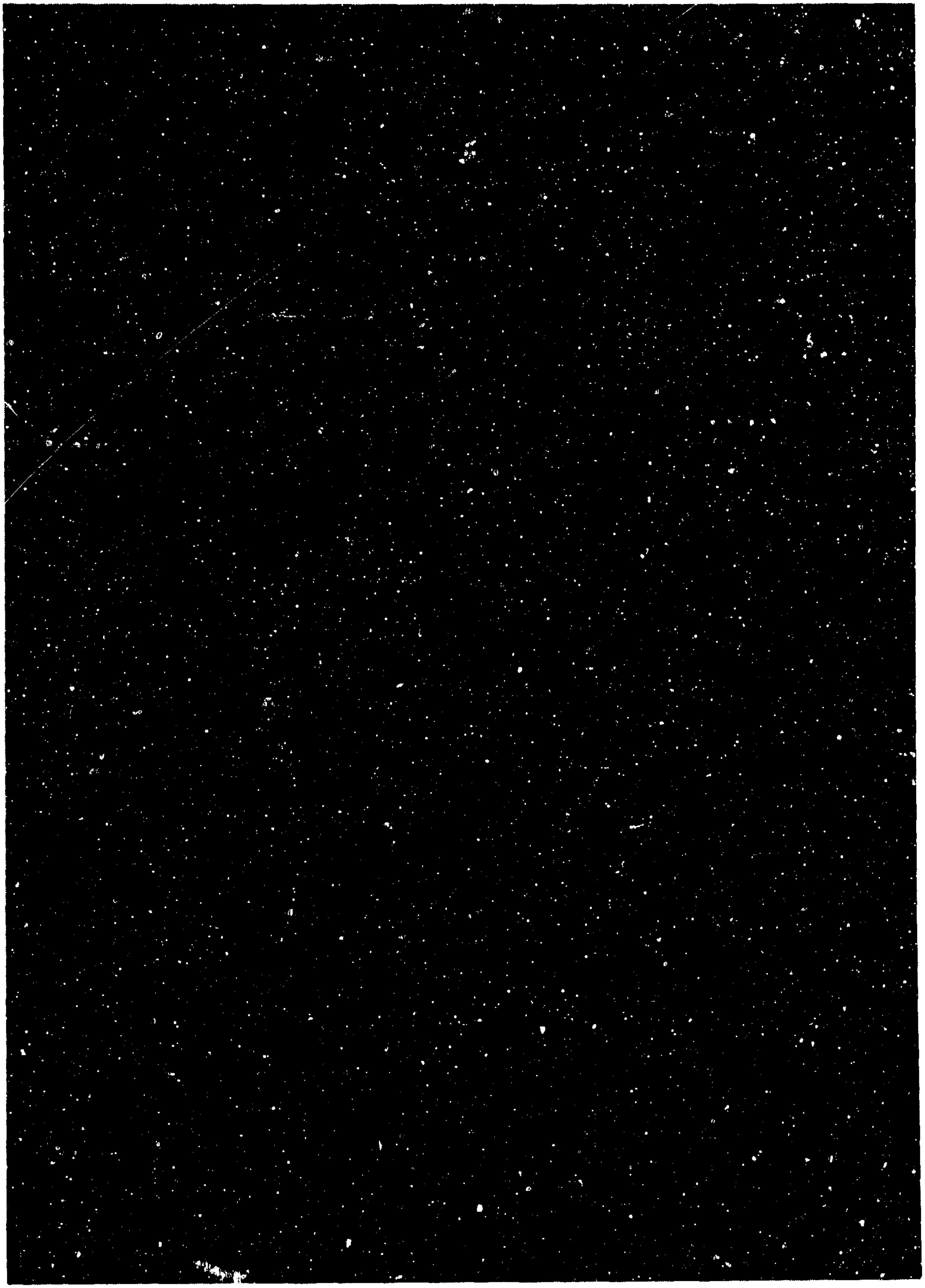


Fig. 20 — Indicator display before fire

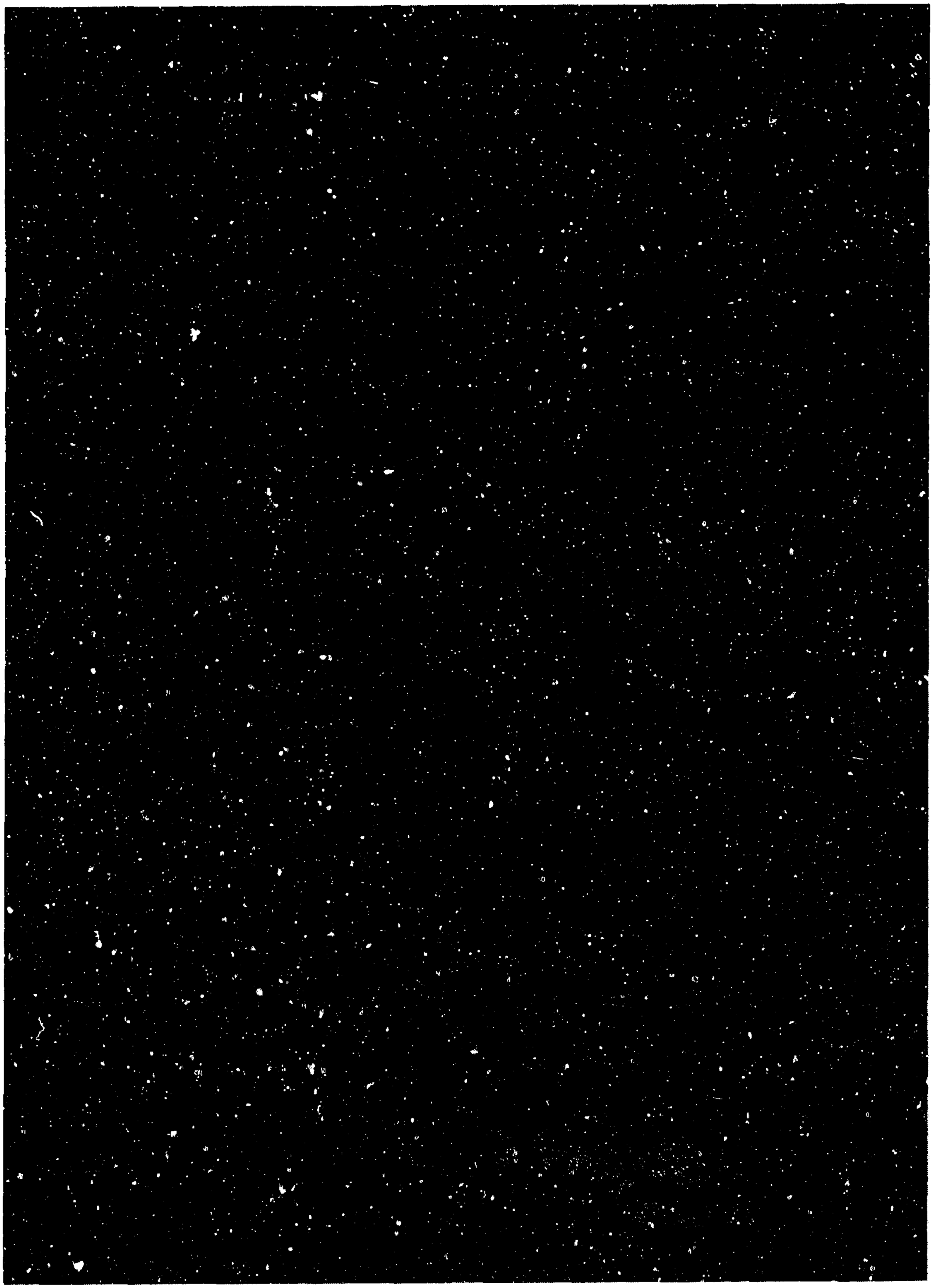


Fig. 21 — Indicator display after the fire

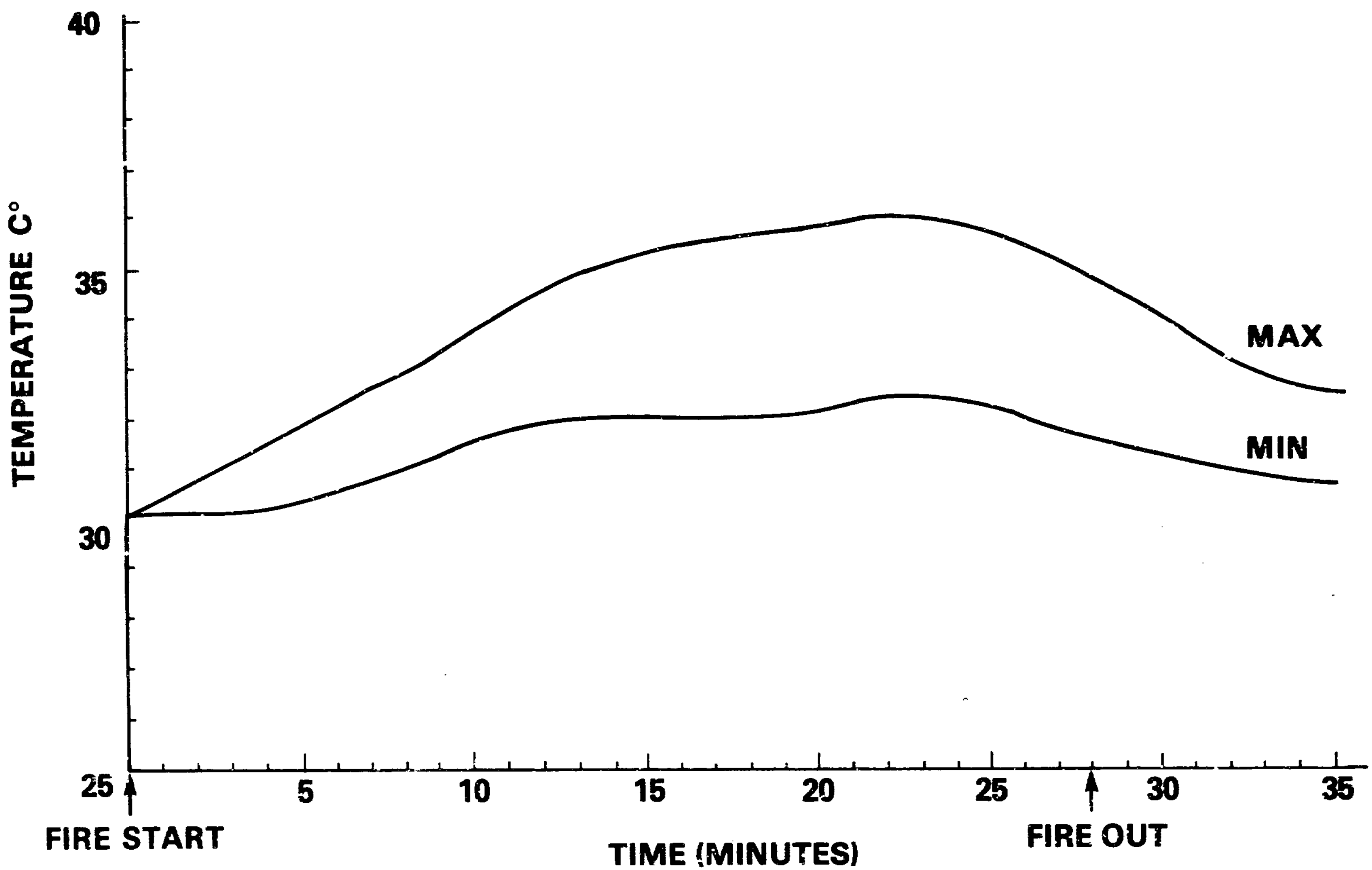


Fig. 22 — Temperature rise inside of indicator and transceiver cabinets during Test 2.